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Production and optimization of bioorganic liquid fertilizer from chicken manure and banana Peels

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ABSTRACT

Bioorganic liquid fertilizer not only increases bioorganic fertility of crops (in comparison to the control and prototype fertilizer), but also accelerates their maturation and nutrient quality. Thus, the present study was aimed to produce bioorganic liquid fertilizer from chicken manure and groundnut husks through aerobic fermentation in open containers. The result indicated that Phosphorus, Potassium (K), Calcium (Ca) and sodium (Na) were found to be significant between bioorganic liquid fertilizer and compost tea (used as a control) solutions. However, there were no significance differences with respect to Carbon (C), Nitrogen (N), and Magnesium (Mg) contents of the solutions. The bioorganic liquid fertilizer produced was evaluated by growing lettuce in pot experiment in two replications. It was indicated that the performance of lettuce irrigated with bioorganic fertilizer solution was performing better than compost tea solution and soil grown plant. Hydroponic growth of lettuce in water solution was shown that significance differences between compost tea and bioorganic fertilizer solutions treated groups in all measured parameters including biomass weight per plant (BMW), number of leaves per plant (NLP), days to maturity (DM) and head weight per plant (HWP). It can be concluded from the present study that biogranic liquid fertilizer can be produced from locally available substrates like chicken manure and banana peels. Small holder farmers can get economic relief, because by using this technology, thus, they can minimize the use of chemical fertilizer which is being expensive and not environmentally friendly.

Keywords: Compost tea, Electrical conductivity, Lettuce, Organic Fertilizers, Plant macronutrients.

1. INTRODUCTION

Natural organic fertilizers used in plant cultivation are characterized by low efficiency and therefore in order to obtain high yield they are soil-applied in large quantities about 7 - 30 t/ha. On the other hand, intensive use of mineral or chemical fertilizers leads to significant mineralization of the soil and to a loss of fertility, and has been brought about pollution of water bodies since the era of green revolution. Thus, for sustainable and organic agriculture searching for new forms of ecologically clean bioorganic fertilizers and liquid utility formulations are useful in organic farming and ensuring the optimization of absorption of mineral nutrients of cultivated plants, obtaining high yields, reduction of chemical load of agricultural land and soil restoration. There are drastic shortages of such highly efficient bioorganic fertilizers, obtained by microbiological processing of poultry manure and animal husbandry and also their liquid utility forms (Chandra, 2005). Bioorganic liquid fertilizer not only increases bioorganic fertility of crops (in comparison to the control and prototype fertilizer), but also accelerates their maturation. At the same time the biological value of products is increasing: the content of vitamins and carotene in vegetables is increased and the nitrate content is significantly reduced. The doses of applying fertilizer are reduced 2.0-2.2 times (PCT, 2013). In light of such justifications the present study was planned to produce bioorganic fertilizer through aerobic fermentation using chicken manure and banana peels.

2. MATERIALS AND METHODS

The experiment was conducted in Biotechnology laboratory, Haramaya University, Ethiopia. 6kg chicken manure was collected from Haramaya University Poultry Farm, and 6kg banana peels was obtained from collection at home. Compost tea that used as a control was obtained from Bate district, Haramaya. Fermentation solution was prepared by mixing 500g sorghum flour to one liter of groundwater following the procedure used by Unnisa (2015). The fermentation process was carried out under aerobic condition in two replications based on the method suggested by PCT (2013) as follow: clamps of oil cake and chopped banana peels were formed in the open container covered with cotton cloth (the proportion of the cake: peels = 1:1). The starting clamp components were successively arranged in layers with a height of 0.4 m each. The formed clamps were sprayed with diluted activated microbiological formulations including yeast and lactic bacteria. The microbial formulations were prepared from yeast powder and coagulated milk (as a source of lactic acid bacteria) with non-chlorinated water in the proportion of 1:50. Mixing and spraying water on the clamp was done periodically. The fermentation process was done in open container at ambient temperature for aerobic microbiological fermentation, until cycle of a fertilizer production completed (being without any flavor).

The output components of the bioorganic fertilizer were left in the open container to complete finishing of the technological process of the fertilizer production. The degree of readiness of the bioorganic fertilizer was determined according to physico-mechanical and organoleptic properties (homogeneity, looseness, lack of smell). When the above conditions are observed the duration of a complete technology cycle was taken around 40 to 50days. Finally quantitative analysis for composition of macronutrients in bioorganic fertilizer was determined as per procedures below.

Determination of major plant macronutrient minerals

Nitrogen contents of fertilizer solution and compost tea (control solution) were determined by the Kjeldahl method consists of three steps: digestion, distillation, & titration. The Phosphorus Content was determined by acid ($HNO3$) oxidation in the presence of vanadium ammonium molybdate. Sodium and potassium were determined by atomic absorption method.

Determination of Quality of Bioorganic Fertilizer Solution

PH measurement was based on procedure used by Patel and Lakdawala (2014) as follow:

Calibration Standard Preparation: two buffers was selected that bracket the expected sample pH. The first near the electrode isopotential point (pH 7) and the second buffer near the expected sample pH. A pH 7.00 buffer pouch was opened or a graduated cylinder was to transfer 30 mL of pH 7.00 buffer into a 50 mL beaker.

Sample Preparation: 40 mL of the sample liquid bioorganic fertilizer was measured by using a graduated cylinder into a 50 mL beaker. The beaker was covered with a watch glass. The electrode was placed in a prepared sample with the electrode tip fully

immersed in the solution. The measure key was pressed on the meter. The pH icon flashed as the measurement was being made. Determination of the quality of bioorganic fertilizer solution based on PH range was based on the standard Table 1.

Table 1 Rating of bioorganic fertilizer solution based on pH values

Category	Range of pH value	Suggestion for remedy of bioorganic fertilizer solution
Acidic	<6.5	Requires liming for reclamation
Normal	6.5-7.8	Optimum for most crops
Alkaline	7.8-8.5	Requires application of organic manures
Alkali	>8.5	Requires gypsum for amelioration

Source: Patel and Lakdawala (2014).

Electrical Conductivity (EC) Measure: A 2:1 by volume method was used to measure EC based on modified procedure used by Rhoades *et al*., (1999). Whereby a volume of mix was measured and twice as much water was added. The electrical conductivity (EC) is a measure of the total soluble salts, or the soluble nutrients (or ions) present in a growing media. The determination of electrical conductivity (EC) is made with a conductivity cell by measuring the electrical resistance of a 1:2 solute: water suspension. The determination of EC generally involves the physical measurement of the materials' electrical resistance (R), which is expressed in ohms. The reciprocal of resistance is conductance (C). It is expressed in reciprocal ohms, i.e., mhos. When the cell constant is applied, the measured conductance is converted to specific conductance (i.e., the reciprocal of the specific resistance) at the temperature of measurement. Electrical conductivity meter & cell measures fraction of the specific resistance; this fraction is the cell constant (K = R/Rs).

Often, and herein, specific conductance is referred to as electrical conductivity, EC:
$EC = 1 / R_s = K / R$.

Determination of the quality of bioorganic fertilizer solution based on EC range was as in Table 2. Electrical conductivity can be converted to estimate total dissolved solids by using the following equation (Detay, 1997):

TDS (ppm) = 0.64×EC (µS/cm) = 6.4×ECmS/cm = 640×EC (dS/m).

Table 2 Rating of bioorganic fertilizer solution based on electrical conductivity (EC)

Range of EC	Rate of bioorganic fertilizer solution
< 0.8 ds/m	Normal
0.8-1.6 ds/m	Critical for salt sensitive crops
1.6-2.5ds/m	Critical to salt tolerant crops
2.5 ds/m	Injurious or toxicity to most crops

Source: Patel and Lakdawala (2014).

Test for bioorganic fertilizer solution

The fertilizer solution was tested by hydroponic growing of lettuce in pots using soil as control experiment. The experimental design was completed randomized design (CRD) in two replications. Soil sample was taken randomly from field and placed in pots. Four lettuce seeds were planted in each pot. In the experimental pots half liter of bioorganic fertilizer was added during planting. However, in the control group no nutrient was applied only 500ml of water was added to each pot during planting. Then both experimental and control groups were irrigated with water as it was needed so as to prevent moisture stress. Thereafter 3 to 4 leaf stage half liter of fertilizer solution was added to experimental group. That is totally one liter of fertilizer solution was used.

Quantitative data were analyzed by using quantitative method such as frequency, percentage and mean and standard deviation using Microsoft office excel and SAS software (Version 9.2).

3. RESULT AND DISCUSSION

Production of Bioorganic liquid fertilizer through aerobic fermentation in Open container

Chicken manure and chopped banana peels (3kg each) were co-fermented in open container covered with cotton cloth (so as to prevent entry of insects) for 45 days at ambient temperature. It was found that 4 liters of bioorganic liquid fertilizer solution were

produced from 6kg (4L/6kg) of co-fermented substrates. Further dilution can be conducted depending on the economy of the user and performance evaluation. This finding was in accordance with PCT (2013) who recommended aerobic fermentation of organic wastes as an efficient process of bioorganic solution fertilizer production.

Determination of Plant Macronutrient Composition of biorganic Liquid fertilizer solution

Macronutrient composition of bioorganic fertilizer and compost tea solutions was shown in Table 3. Phosphorus (P), Potassium (K), Calcium (Ca) and also sodium (Na) were found to be significant between bioorganic liquid fertilizer and compost tea (used as a control) solutions. However, there were no significance differences with respect to Carbon(C), Nitrogen (N), and Magnesium (Mg) contents of the solutions. It also indicated that percentage macronutrient compositions of bioorganic fertilizer solution were found to be greater than those of compost tea solution in all studied macronutrients. This finding was in accordance with Monisha and Rameshaiah (2016) who produced liquid fertilizer from vegetable waste.

Table 3 Macronutrient composition of bioorganic fertilizer solution and compost tea

Treatment	P	K	Ca	Mg	Na
compost	1.13±0.02b	2.31±0.19b	3.40±0.02b	1.25±0.01a	0.91±0.05b
Bioorganic	1.19±0.09a	7.02±1.07a	5.20±0.68a	2.57±0.61a	4.89±0.03a

Means followed by same letter within a column were not significantly different at 0.05. Probability level based on DMRT (Duncan's Multiple Range Test).

Determination of the quality of bioorganic liquid fertilizer

The quality of biorganic liquid fertilizer solution produced in the present study was measured with respect to PH, EC and C:N ratio as in Table 4. It was indicated that both compost tea and bioorganic liquid fertilizer solutions fulfill the basic requirements of plant macronutrients with respect to electrical conductivity and C:N ratio. However the PH needs adjustment to the neutral range between 6.5 to 7.5 However, further evaluation of fertilizer should have to be done by conducting field experiments for various crop plants. Since fertilizer requirement depends on nature of the soil, crop plant types and other environmental factors. The carbon content of fertilizer solution in the present study was found to be 43.70% (Table 4). The determination of natural carbon in composts serves in an indirect way as measure of accessible nitrogen. In most of the fertilizer cases the minimum carbon content or organic matter was found to be approximately 6-7% (Monisha and Rameshaiah, 2016).

Table 4 Quality of liquid fertilizer solution

Treatment	PH	EC	C	N	CN
Compost	5.54±0.37b	0.43±0.03b	29.60±3.25b	4.47±0.16a	6.65±0.97a
Bioorganic	8.81±0.01a	0.72±0.06a	43.70±2.26a	4.87±0.52a	9.06±1.43a

Means followed by same letter within a column were not significantly different at 0.05. Probability level based on DMRT (Duncan's Multiple Range Test). PH: power of hydrogen; EC: electrical conductivity; C:N: carbon to nitrogen ratio.

Testing the bioorganic liquid fertilizer through pot experiment

The bioorganic liquid fertilizer produced was evaluated by growing lettuce in pot experiment in two replications. It was indicated in Table 5 that the performance of lettuce irrigated with bioorganic fertilizer solution was performing better than compost tea solution and soil grown plant. Above ground biomass per plant (BMW), days to maturity (DM) and Head weight per plant was found to be significant for soil grown plant. However, there was no significance difference for number of leaves per plant (NLP). For hydroponic growth of lettuce on sawdust (as inert material), significance difference between compost tea and bioorganic fertilizer solutions was observed only for BMW and DM. No significance difference with respect to NLP and head weight per plant (HW). In contrast, Hydroponic growth of lettuce in water solution was shown that significance differences between compost tea and bioorganic fertilizer solutions treated groups in all measured parameters including BMW, NLP, DM and HWP.

Similar study was conducted by Unnisa (2015) who conducted pot culture experiments in triplicate to test the toxicity of the organic liquid fertilizer for seed germination. Liquid fertilizer has many advantages because of easy process, inexpensive and no side effects. The resulting benefits are very likely to fertilize crops, to maintain the stability of nutrient elements in the soil and reducing the bad impacts of chemical fertilizers. In addition to a liquid fertilizer that can be sold in the market, liquid fertilizer can be used for agriculture purpose or in the premises for plantation.

Table 5 Performance of lettuce

Medium	Treatment	BMW	NLP	DM	HWP
Soil	Compost	16.91±1.87b	6.00±1.41a	53.00±1.41b	4.03±0.67b
	biorganic	21.04±0.39a	7.00±1.41a	47.00±1.41a	7.10±0.42a
Sawdust	Compost	22.95±0.86b	4.50±0.71a	42.00±1.41a	3.42±0.74a
	Bioorganic	25.76±0.51a	6.00±1.41a	37.00±1.40b	5.34±0.23a
Hydroponic	Compost	23.28±1.48b	5.50±0.71b	44.50±0.71a	6.89±1.46b
	Bioorganic	29.56±1.57a	9.00±1.42a	31.00±1.41b	9.82±1.39a

Means followed by same letter within a column were not significantly different at 0.05. Probability level based on DMRT (Duncan's Multiple Range Test). BMW: biomass weight per plant (gm); NLP: number of leaves per plant; DM: days to maturity; HWP: head weight per plant.

4. CONCLUSION

The present study has produced bioorganic liquid fertilizer solution from chicken and banana peels through aerobic fermentation in open containers. Comparison of mineral composition of bioorganic liquid fertilizer and compost tea solutions with the standard for major macronutrients requirement of plants indicated that the composition of both fertilizer solutions in the present study satisfies the standard with bioorganic liquid fertilizer being higher in mean values for most of the studied mineral plant nutrients. However the PH of both solutions need amelioration. It can be concluded from the present study that biogranic liquid fertilizer can be produced from locally available substrates. Small holder farmers can get economic relief, because by using this technology, they can minimize the use of chemical fertilizer which is being expensive and not environmentally friendly. The commercially available chemical fertilizer supplies not only limited number of macronutrients but also expensive. Thus, the present study has produced quality organic fertilizers from locally available substrates having diverse composition of minerals. Small holder farmers can easily produce it locally and use it so as to reduce dependence on chemical fertilizers and their devastating effect on the environment. However, further studies are required to optimize fermentation durations and conditions.

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